Electronics Equipment Integration and Prototype Building

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Lecture - 22
Introduction to sizing and fits

Hello, I am continuing where I had come so far in my earlier presentation or lecture. One of the first thing is saying from a simple two dimensional flat representation or earlier engineering drawings, we have now progressed towards 3D. The advantage of 3D being that it is easy for us to conceive something in a product like this no.

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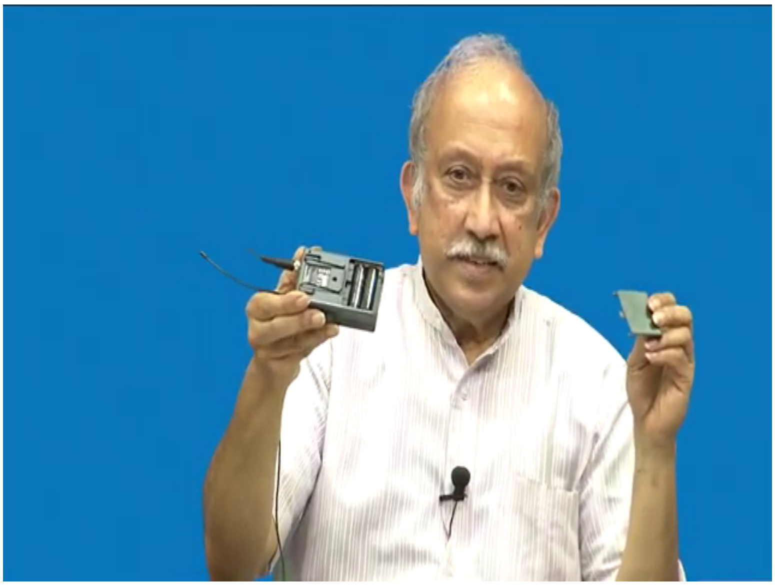

We can conceive the product very well and try to manufacture it and using the same drawings which we have made, it is possible to now go ahead and produce the parts in large numbers.

And, at this point we will end up with something which is, what you call developed very well and everybody understands about it. One of them is making things or mass production.

You have two ends two extreme options: one option is if there in reasonably large numbers and strength and such things are not that important and you can tolerate certain changes in thickness, you can go for plastic injection modeling. Allow me rather at this minute no, not to think about saying yes they can be made in so on and so on like that. One variation of this if you want strength is to use injection molding or die casting in a metallic devices.

So, earlier automobile things and all are typically non-ferrous die casted, die cast materials. And, in the case of this, this is a simple I will say inexpensive plastic injection molded part. The problem comes is normal times there is no issue at all in dealing with this thing, but kindly remember that this phase which is a cover. Lot of retailing has gone into it and this of course, the professional phase there is what you call wireless thing is a professional phase, hence lot of detailing and careful amount of things have been done and the tooling for this and the material for this are costly and it is constantly being improved.

In this case the enclosure is one part of it then the electronics inside and then the r f and how it come to the works and all is another type. And, if you come to toys there are very inexpensive toys where things are made with really low cost plastics. Now, one thing you will notice is this has been made in two different settings, but miraculously these things match. How do they match? This is where this whole lecture is about general type of fits and tolerances.

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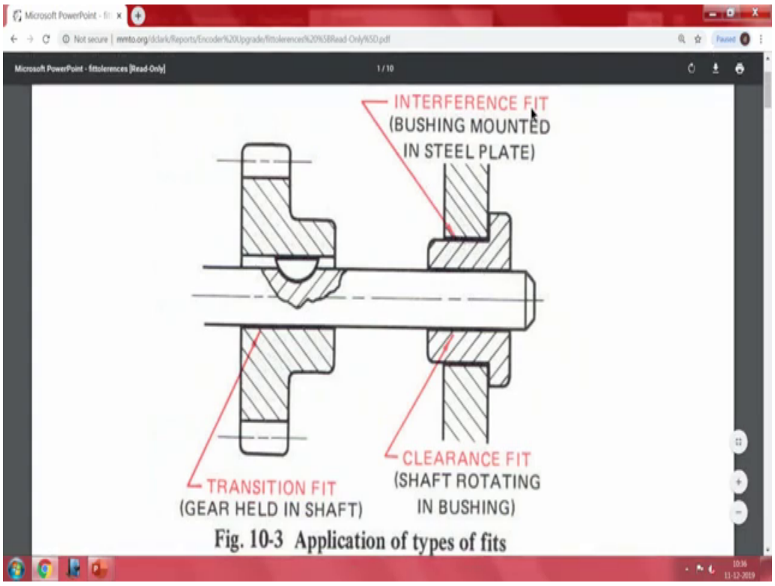

Fig. 10-3 Application of types of fits

Kindly look at my monitor one of the things you will notice is this has been derived from actual practice. So, this in a comprehensive way; this has been given all three fits are shown here. If you remember, I mentioned this about how to fit a bearing into a housing. So, this is the actually the starting point. If you notice here there is something has been done here to make sure that any bush usually, it will be a bond bush otherwise called gunmetal; its a made out of a one type of bronze material. Traditionally, this was done earlier and this itself is directly a bush which is used for various bearing type of applications.

So in fact, you have bearing material separately the processing, then the metallurgy itself is slightly different. It is a softer material and it runs well and then it there is something about the tribology of it saying, how it takes oil and all that. So, you will see the outer part of it is called an interference fit. So, you push something and then you almost force it into that slot.

And, the other side we have here a clearance fit. A clearance fit is actually something, which is a rotating inside. Seen this, there is a beautiful option for it to rotate.

We are not going to put a separate ball bearing or anything here no there is no necessity of a ball bearing here. What is done is? You make a sufficient amount of a clearance here. So, that is what the word clearance is and the other extreme is a transition fit; meaning, sometimes it may lock sometimes it may not lock and we add an extra another item for it to hold it in place.

So, all these types are possible and depending on this thing in this particular thing is a key and there is a key way and then how we lock it inside is very very critical. Now, if I come down, this is what I was trying to talk to you yesterday.

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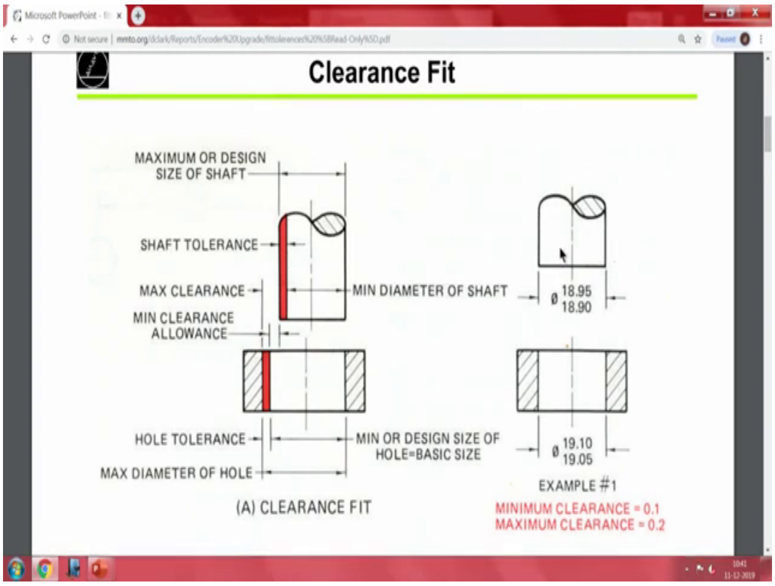

So, you will notice here that the whole itself can have a range of what you call permitted dimensions which come out based on the type of machining you use. Normally, if the machine is kept under one particular setting and the tools and all are good and the material is good and closely monitored, this follows a very average normal yield. It may be I have I am not talking about the statistical think about whether it is a bell curve, it is a normalized curve or anything, but it does follow certain things what you call certain yield which you can get from the machine.

Similarly, we have a shaft which it goes inside like this. So, you will end up with a very peculiar things saying this is the tolerance that has been given, this tolerance is represented here over 5 millimeters. And, similarly there is a tolerance which is given here whole tolerances that is also again and O 5 gap has given here, now when you actually try to assemble any what you call the shaft to any of the hole. So, something starting here you understand something starting here to this thing will be possible.

So, depending on the process, what has being adopted in the production shaft and depending on how you have select these things and put it together somebody has to have a good working knowledge of these things. Earlier it was easy, easy meaning; somebody will present it like this in a indication like this. So, this is where the what do you call things what I talked to you about saying there are norms that are there about the way you mentioned the what you call lines.

The way you mentioned this sectioning, the way you mention your tolerances, the way you mention the allowance that is there and so on like this have been adopted separately depending on how things have been progressed earlier. In manual craft usually things are assembled together and a little bit of running in is given.

So, it does not matter, if you are trying to make a grinding stone at home with a what you call an opening and then you have a that grinding stone inside it will behave one way and things like a puzzle and mortar the things are very very huge, there is no issue at all. But the moment we have come in to the industrial revolution and you have to end up with the large number of interchangeable parts this business of clearance and tolerances has become very very real.

Now, the something which is very related to this is you cannot arbitrarily give anything you want here. Because, when it is produced in the machine shop, somebody has to set the machine and somebody has to inspect the parts saying which is acceptable, which is not acceptable. This is where to make a little a things little more inexpensive the concept of designating a batch came saying in fact, you can have all these things you know saying something which is on the lower and something which is nominal something which is higher and call it type A B C D.

Where the fit is very very critical as in the case of a cylinder and a piston or in the case of a cylinder liner, the whole thing is stamped on it after the measurement is done they stamped the designation on it saying this comes under the class A, meaning this follows this and so on. But then normally, earlier it was easy just had to make a drawing probably dimension it and write what you think was a reasonable amount of thing directly.

But now, once this CAD, the way of designation came about and especially both in the case of simple two dimensional or drafting representation versus actual 3D assembly representation, all this is to be carried out with due care. You cannot independently change anything you cannot change what is written there.

If you change it leads to a lot of problems. This is where the full fledged solid modulars with assembly and with various other checks have developed all these things inside automatically you can mention the class of fit to that is required. Now, go to the let me to the transition fit.

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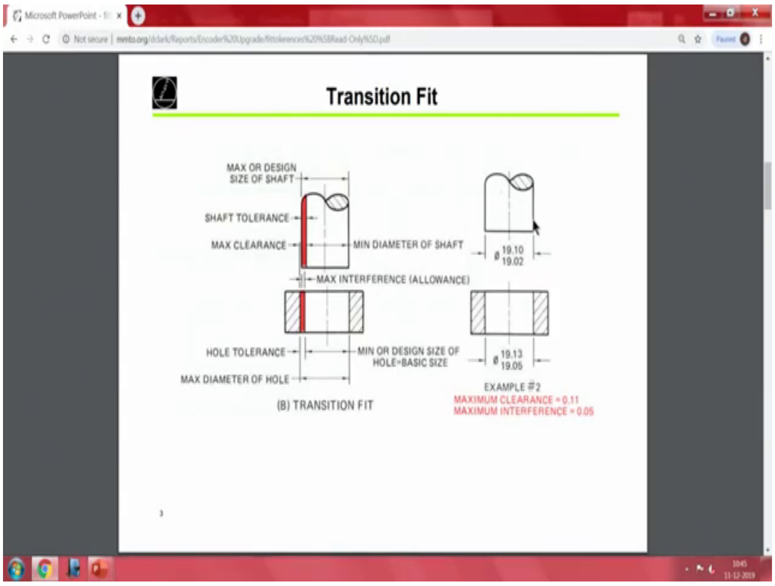

If you see here compared to the other one, you will notice here that both possibilities are there it is. If you take the shaft switches on the maximum diameter and then you take a this hole which is of the minimum diameter under some conditions an interference can occur. Now, it is for you to decide how to deal with it and so on. Right now, I will not talk about it I am just talking to you only about such a thing is called a transmission fit.

So, if you go here and the way things are made, we just we tend to give a some designation there and this is where things have changed a little over the years. It is not correct for you to arbitrarily give what you think is a reasonable what you call way of mentioning these things. The problem being to carry out this both the operation to carry out the inspection and trying to make the assembly this will become very uneconomical for you, if you keep on narrowing these allowances and the tolerances; if you keep narrow while it can in principle you can make it a 0 0 0 or something it will be very very expensive to make such a thing.

So, depending on the type of running and the type of thing, we need to make something. Now you come to genuine interference fit.

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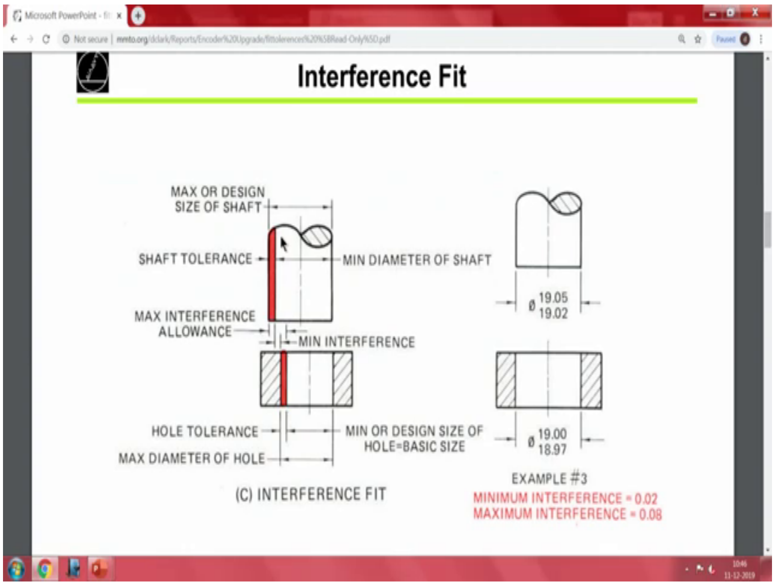

In the case of the interference fit under all conditions, under all conditions; there must be completely joint together and a lock itself only. This is called a pure interference fit. So, when if you remember the first example; there was a bearing slew fitted into a plate there under all conditions it should maintain itself well. Here, various types of things are there. So, have a look at this nice interesting thing I have.

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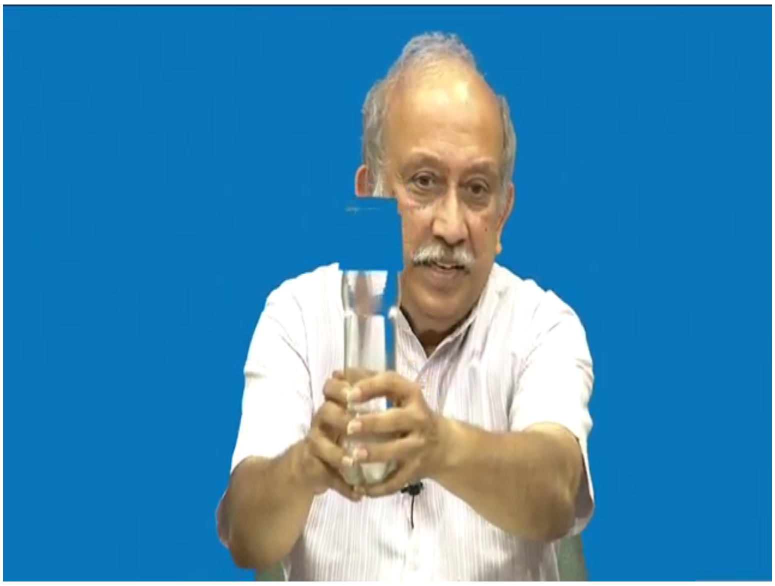

Sir, can you please show this? Say this oh it has got merged in it. So, maybe I should put it here very nice and interesting thing. Do not worry too much about the design. This has been made by a company and given as a nice go away compliment. I am trying to take a sip, good water with or without sprit tastes good.

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Now, if I see this, this is made by another company. They are probably competitors they have ensured that this will not fit this and they have patented the thing this thread and all they have patented. You have got my point, from purely from commercial point of view they have made a design by which it will not fit under all conditions you understand and naturally absolutely no problem even by mistake if I do it will not come which will make me come to a very very interesting aspect of this fabrication of this.

You will notice that this one is made by a what is called blow molding. Several of your toys, several of your things in your house, there is a particular die in which something is inserted and it blows and variations here are very very high understand no. The amount of things what you have to get is variations are very very high.

Further is the tremendous amount of design involved in it same, I am not sure whether its a previous year polypropylene bottle, same polypropylene bottle when it is used for holding water under normal pressure the thicknesses and things are different. And, when you would like to put carbonated or soda or many of our colas and all that this thickness is are different and cap is made by very traditional injection molding.

You see here this cap also has an injection molded cap, that is an injection molded cap. Now, how do you ensure that on all conditions any bottle will fit any cap that is there and then given the small cavy that I said this whole thing is made by blow molding and hence dimensions are not very stable. The issue is that is only part of the story, the part of the story is that though this part of it is blow molded; however, the former that is required for this one is injection molded.

If you see carefully, probably we will notice a flash and then you know how the thing is opened and all, how it is taken from the mold. And, then you will notice that this two that perfect amount of fit has been ensured and usually this thread formational will say is very very special and then we have something here and whole thing sits perfectly. Seen that because, here the tolerances in the injection molding are very good, here this has slightly softer materials. So, it can actually take little pressure and you know expand and fit the thing this remaining part is different.

From here onwards actually it is a former that has made it looks like a longer tube like thing a little like an injection syringe then it is kept inside the what you call the injection mold and then some gasses in let into this. This is warmed up and it takes the shape afterwards and various ways are there, how to take it out and all if you are curious, you can just look it up, but what I would like to say is that a very routine ordinary thing on the among your collection, this needs lot of patients in designing and not just designing.

Now when we come to this if you see the way we show it on the on drawings this is very very clear. So, earlier I thought life is easy all we have to do is we go to the fabrication shop, we will go to the supplier and ask him what do you think is the best thing. So, I just erase you know I have something called a modification or a change node here. I say this diameter 19 millimeters, the tolerances have been changed, but the moment this cad system came it is inconvenient to just go and rub out the dimensions and change it.

Instead you are expected to use a different thing. This is where it comes to advantage of having solid modular cads. If you take any of the things large number of them there, but in the parts where we live both the several of them specifically, solid edge, solid works both of them are I think from Siemens as well as a desalt and so many other people make this new solid modulars with what is called associative dimensioning by directional associated dimensioning meaning; if I change the dimension here or the tolerance here, the shape of this part and it changes automatically.

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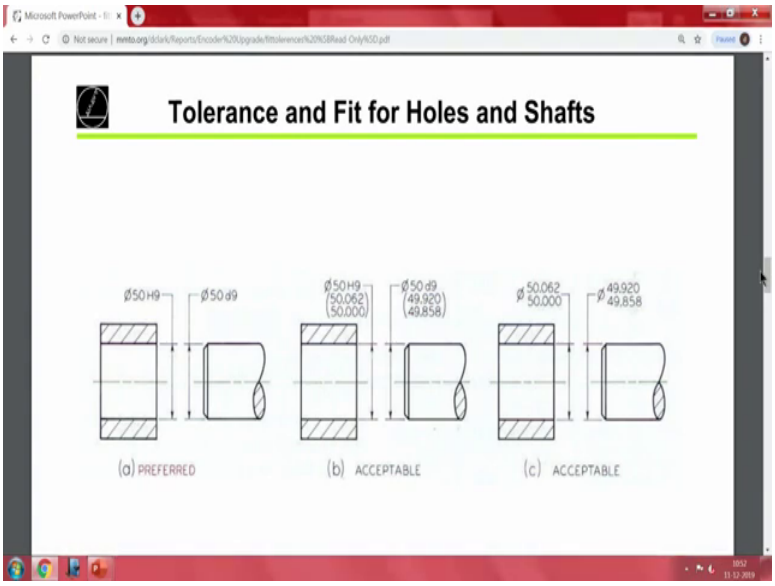

Similarly, if I change the part this dimensions change automatically which helps in certain conditions we can look at it the very professional things also take care of various types of this toleranceing and fit for holes and shafts. You have seen something about this here which I was trying to tell you all the time probably it did not make much sense except people are actually in the field and this thing, if he had waited a little and this thing you will know what it is I was trying to talk to you about. This is called a designation of a fit.

So, a nominal dimension has been shown here saying it is a 50 millimeter nominal and from the nominal hey letter designation, you will notice that capital H and 9 has been specified here and in the case of the, the shaft which goes inside a small lowercase letter and another number has been designated here. Combinations of this have been standardized with different types of materials, different types of operating conditions and so on.

Occasionally, people write down the actual values. This will help in case you are making a small number of numbers and you have a screw gauge or some other array profile projector with which you measure these dimensions. So, that you know where we stand.

You understand no the both the dimensions the plus o 6 2 and the nominal this thing has been mentioned here in this case, in the case of shaft; while the nominal is 50 mm, what is designated here you have seen this 49.920 has been given here which is. People can read it and all that, but the thing is this corresponding this d 9 these things have to be perfect.

If somewhere in the previous drawing, if we change, we may end up with a little problem and imagine this part comes under in one a drawing, this part comes under in one drawing very difficult to manage this things every time. This is also acceptable instead of showing the nominal, the things have been explicitly written here saying this is it the thing, but the most preferred way is just to write the H9 and d 9 designation.

So, depending on your way of dealing and all that where each of these we have thread gauges, we have go, no go gauges and coming back to my example of it, if we have a thread gauge imagine this part of it has to be checked deliberately I have that thread gauge for this will have something like this. On one end of the road, we will have a little larger thing saying it should not go inside if it goes inside; that means, this is larger the other end of it there will be a little smaller saying it must go inside.

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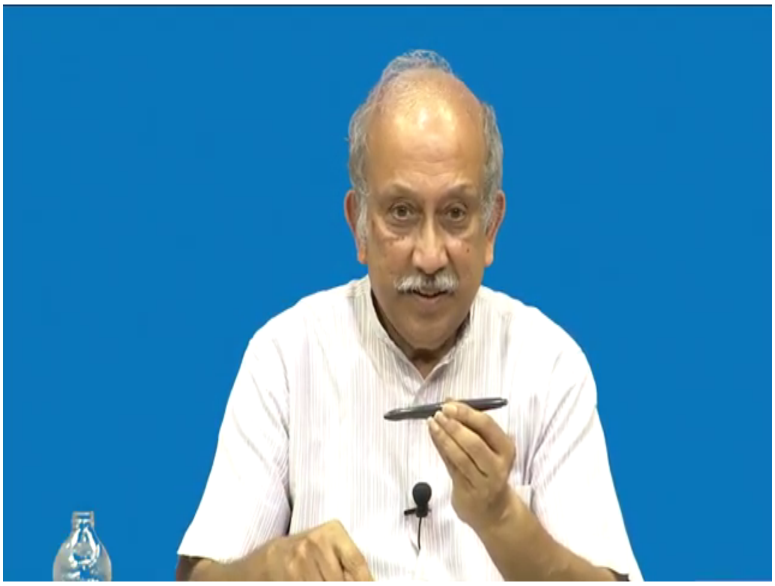

So, that will a imagine I will try to get a picture of it, imagine large hexagonal holder and one side you have a thread which follows whatever is shown here, another side and another thread which follows the other designation. I can just quickly put it; take random sampling acceptable quality level. If I get a bin of say 10000 parts I randomly select one try it here and pass all of them that is statistical. In statistical it has been what you call designated saying which should be a quality level.

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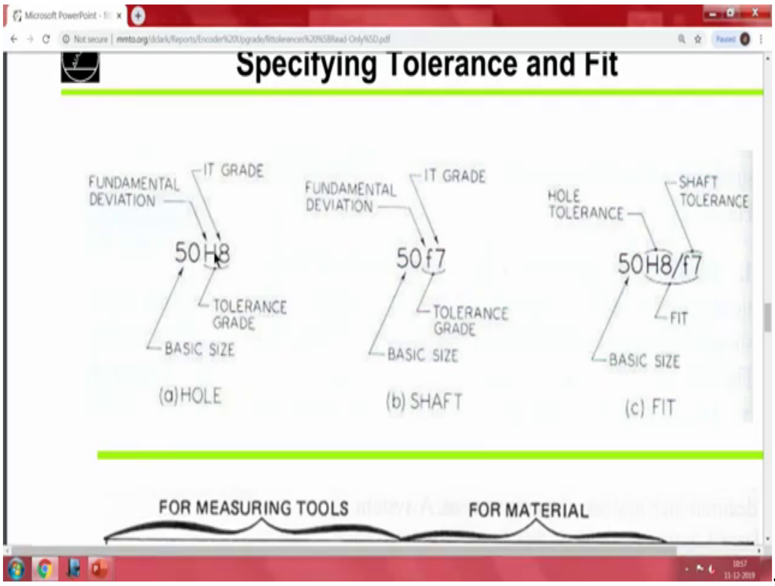

Further if I go down now, you see here. At the extreme on the what you call the hole basic size has been maintained what you call, has been mentioned here and the tolerance grade including a letter designation and including a type of what is the type of fit that we require is mentioned here. H and all comes to things which are on one direction. Similarly, in the case of the hole, a smaller letter and then a different designation has been given and which I was trying to tell you is generally this combination of this saying H 8 f 7 on 50 is the wanted fit.

Now, we now come in to an important thing will the 50 be the same in case, I am sorry, will H 8 f 7 be the same incase it is a fine screw. Extreme fine screws probably what you like to find in a thing like your spectacle frames or you might find in your pen or you may find in your automobiles you understand no.

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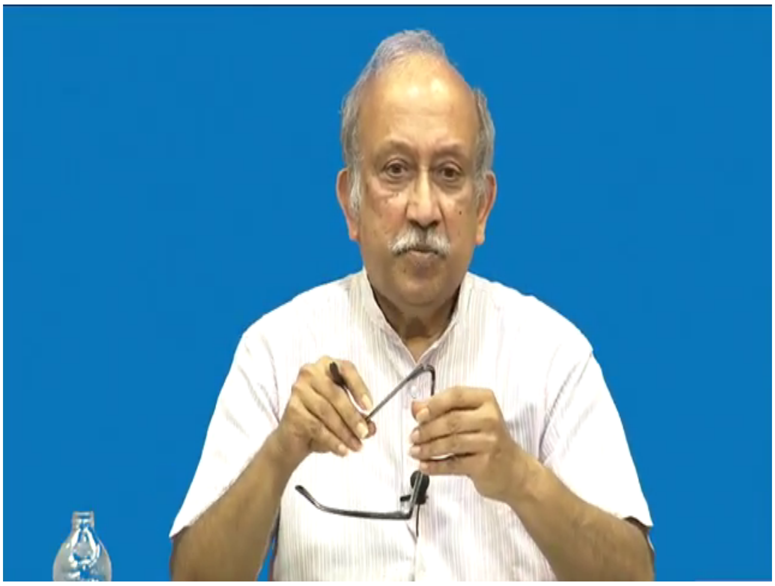

This is extremely small and in fact, the diameter of this maybe is some 1.2 millimeters or 0.81 1.2 millimeters, is this the same for it? Yes, because they IT grade depends exclusively on the basic diameter up to say 0.1 mm to 0.4 mm it is one range and as it comes to 1 mm then from a say every 1 mm after that, later on depending on the type of trade depending on the type of material and so on these tolerances are cataloged and available in a book.

In fact, if you open the thing we have a huge table which shows the type of tolerances which are specified and large manufacture for measuring tools and then for materials for fits and all that no.

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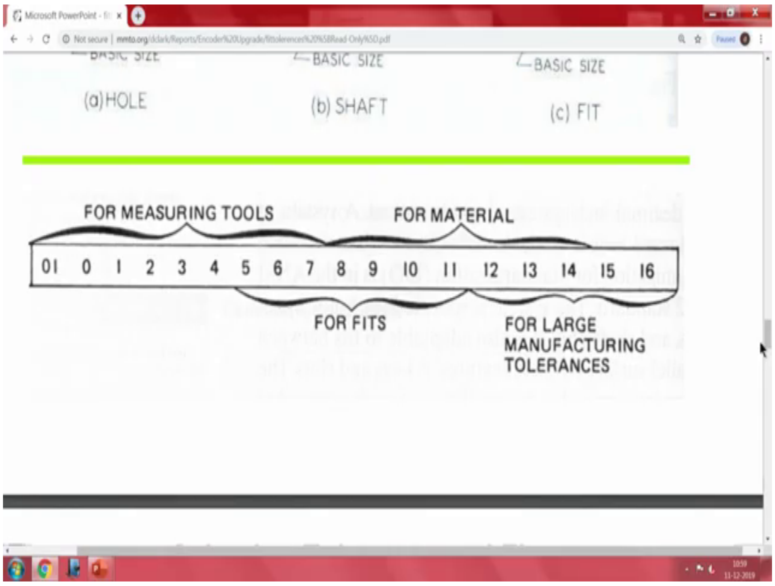

So, many of them have been specified. You understand know? Not easy it is tough, tough.

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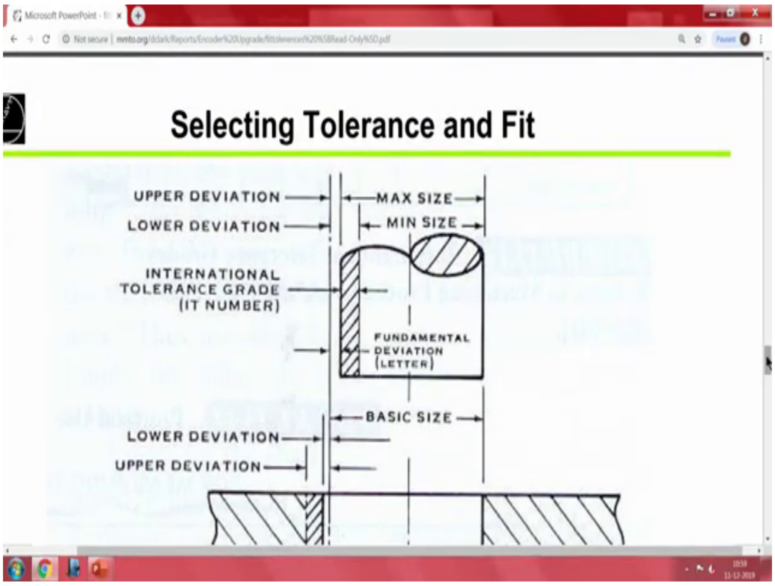

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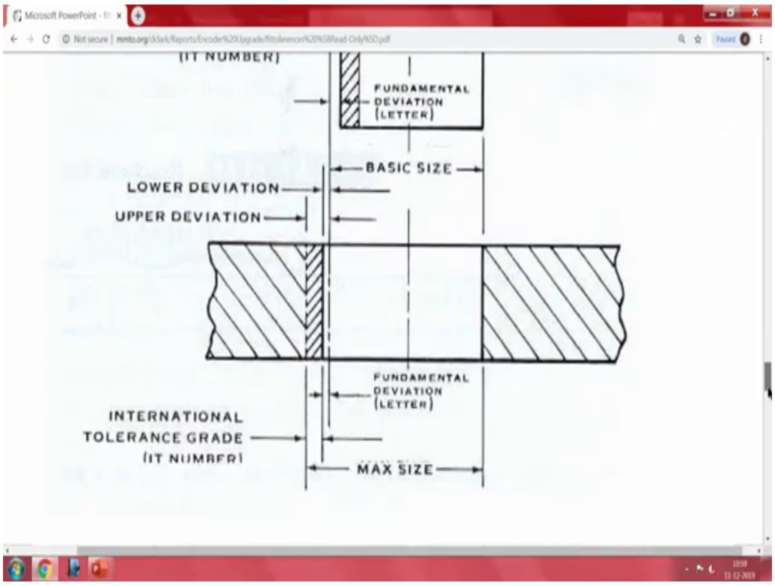

Here comes the, how do you select a particular tolerance and fit? It comes to this chart which I was talking to what it is a huge chart.

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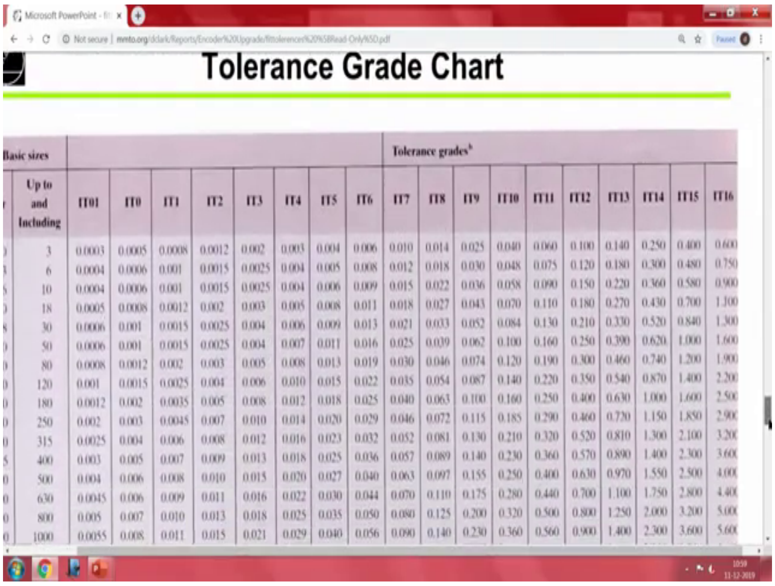

Tolerance Grade Chart

Basic sizes	Tolerance grades[b]																
Up to and Including	IT01	IT0	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16
3	0.0003	0.0005	0.0008	0.0012	0.002	0.003	0.004	0.006	0.010	0.014	0.025	0.040	0.060	0.100	0.140	0.250	0.400	0.600
6	0.0004	0.0006	0.001	0.0015	0.0025	0.004	0.005	0.008	0.012	0.018	0.030	0.048	0.075	0.120	0.180	0.300	0.480	0.750
10	0.0004	0.0006	0.001	0.0015	0.0025	0.004	0.006	0.009	0.015	0.022	0.036	0.058	0.090	0.150	0.220	0.360	0.580	0.900
18	0.0005	0.0008	0.0012	0.002	0.003	0.005	0.008	0.011	0.018	0.027	0.043	0.070	0.110	0.180	0.270	0.430	0.700	1.100
30	0.0006	0.001	0.0015	0.0025	0.004	0.006	0.009	0.013	0.021	0.033	0.052	0.084	0.130	0.210	0.330	0.520	0.840	1.300
50	0.0006	0.001	0.0015	0.0025	0.004	0.007	0.011	0.016	0.025	0.039	0.062	0.100	0.160	0.250	0.390	0.620	1.000	1.600
80	0.0008	0.0012	0.002	0.003	0.005	0.008	0.013	0.019	0.030	0.046	0.074	0.120	0.190	0.300	0.460	0.740	1.200	1.900
120	0.001	0.0015	0.0025	0.004	0.006	0.010	0.015	0.022	0.035	0.054	0.087	0.140	0.220	0.350	0.540	0.870	1.400	2.200
180	0.0012	0.002	0.0035	0.005	0.008	0.012	0.018	0.025	0.040	0.063	0.100	0.160	0.250	0.400	0.630	1.000	1.600	2.50
250	0.002	0.003	0.0045	0.007	0.010	0.014	0.020	0.029	0.046	0.072	0.115	0.185	0.290	0.460	0.720	1.150	1.850	2.90
315	0.0025	0.004	0.006	0.008	0.012	0.016	0.023	0.032	0.052	0.081	0.130	0.210	0.320	0.520	0.810	1.300	2.100	3.20
400	0.003	0.005	0.007	0.009	0.013	0.018	0.025	0.036	0.057	0.089	0.140	0.230	0.360	0.570	0.890	1.400	2.300	3.60
500	0.004	0.006	0.008	0.010	0.015	0.020	0.027	0.040	0.063	0.097	0.155	0.250	0.400	0.630	0.970	1.550	2.500	4.00
630	0.0045	0.006	0.009	0.011	0.016	0.022	0.030	0.044	0.070	0.110	0.175	0.280	0.440	0.700	1.100	1.750	2.800	4.40
800	0.005	0.007	0.010	0.013	0.018	0.025	0.035	0.050	0.080	0.125	0.200	0.320	0.500	0.800	1.250	2.000	3.200	5.00
1000	0.0055	0.008	0.011	0.015	0.021	0.029	0.040	0.056	0.090	0.140	0.230	0.360	0.560	0.900	1.400	2.300	3.600	5.60

So, not easy, is it not? As you go to the left things are extremely expensive, very very expensive and then it goes to the right things are little inexpensive, understand. Imagine, you would like to make a something which you push into a wall followed no something which you push in to a wall if you give a very tight tolerance it is pointless very very expensive. Instead, if you give it toward the right it is easy that is the most of the dowels most of the that plastic or wooden things which you push into a wall will be they all towards the other extreme.

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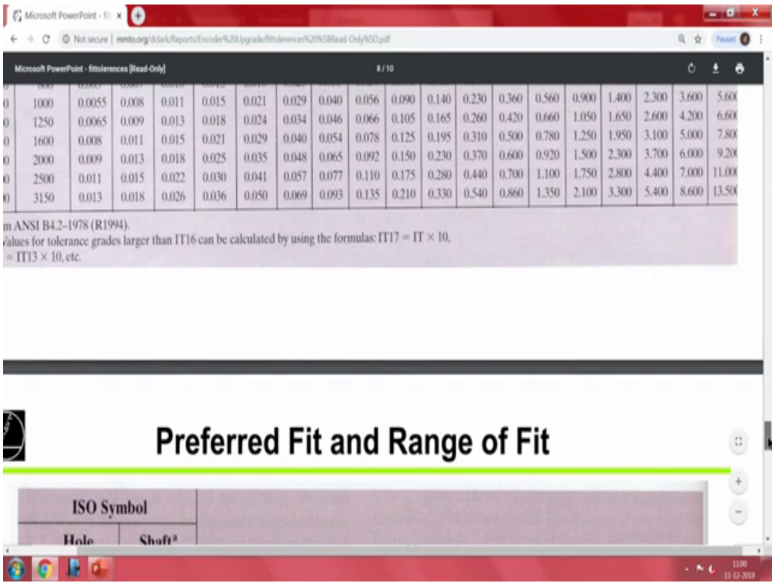

Now, I feel you read this right now on your own.

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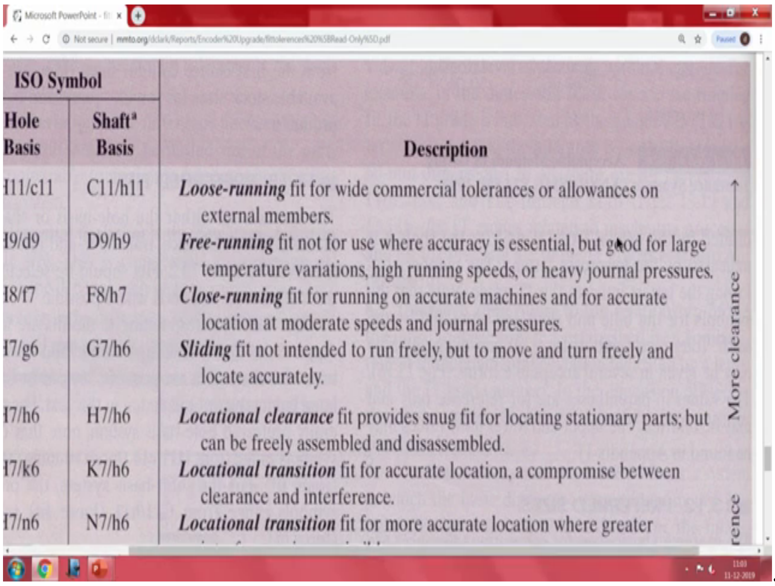

ISO Symbol		
Hole Basis	Shaft[a] Basis	Description
H11/c11	C11/h11	***Loose-running*** fit for wide commercial tolerances or allowances on external members.
H9/d9	D9/h9	***Free-running*** fit not for use where accuracy is essential, but good for large temperature variations, high running speeds, or heavy journal pressures.
H8/f7	F8/h7	***Close-running*** fit for running on accurate machines and for accurate location at moderate speeds and journal pressures.
H7/g6	G7/h6	***Sliding*** fit not intended to run freely, but to move and turn freely and locate accurately.
H7/h6	H7/h6	***Locational clearance*** fit provides snug fit for locating stationary parts; but can be freely assembled and disassembled.
H7/k6	K7/h6	***Locational transition*** fit for accurate location, a compromise between clearance and interference.
H7/n6	N7/h6	***Locational transition*** fit for more accurate location where greater

Come from left to the right, you keep reading it. You will know my voice may be a little irritating. So, you see hole basis, shaft basis and so on and so on. So, we have things like H 11 c 11, saying there is a loose running fit for wide commercial tolerance or allowance on external members; so, again, once again simple commercial.

Very easy to achieve does not cost too much money and if you are starting from the what you call I will I will leave you to read the bottom part towards the end of this. And locational or sliding fit yeah, there is a there is something which is quite important free running you are not for use where accuracy essential. But good for large temperature variations, high running speeds are heavy journal pressures

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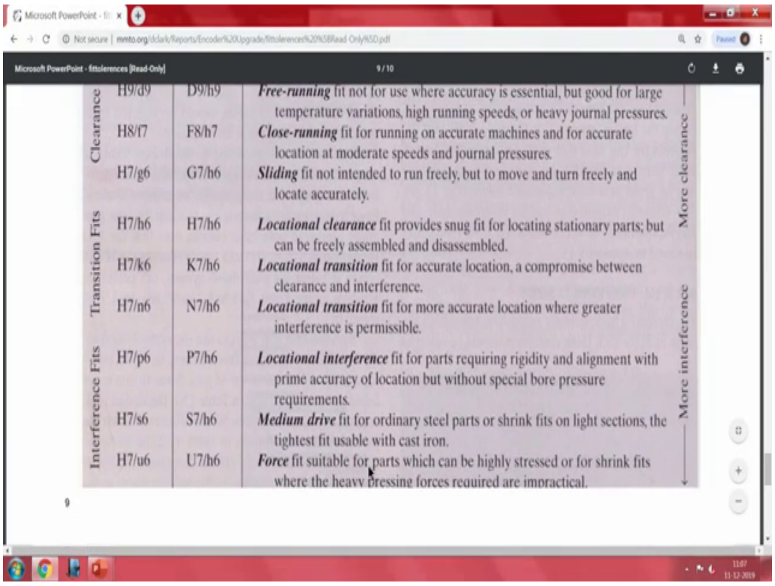

Loosely this has been taken from one of the what do you call the general engineering descriptions, but all of these are based on actual practices. You understand no, actual practices on how to make things work. Then somebody has actually taken a bush, then they have found out they have run it on a typical if it is a large number they are run it on a automate called as switch automate or any of them depending on where you come from average ports and then we have any number of this small machines which quickly maintain all of these things on the other end we have accurate machines close running fit.

And, for accurate location at moderate speeds and journal pressures typically, you are sewing machine at home may have this type of a close running fit. You have seen not many bearings the way we know no not many roller or ball bearings a little bit there in that machines. What will require is actually there is a bush and then you can rotate it and usually there is a in case there is a let us say this is a bush like this then there is a shaft which is moving inside and usually that whole thing moves inside, there is a small opening for you to lubricate it.

In that condition this is the best and original singer machines and all that. They still work a 100 years after they have been made and sold and then they work very very well without the least amount of any problems. They continue to work like this. That is because somebody has paid attention to two details one of it is the type of journal that you need it and the how easy to achieve it and the type of that sliding part inside this.

Now, you may come to know the things are it things are so lose, how can we make these things work there it is not every time things are made such that they are non-recoverable non-repairable or you know we can tolerate with the yield usually, what is called a second operation including a reamer is passed on to that.

If the shaft is made standard we will not touch the shaft too much because making it there is a problem; however, if there is an opening you can make what is called a proper reamer and adjust it to that. So, imagine you need to make a 3.8 mm hole. Probably it is made into 3.75 and you have a special reamer which exactly goes inside and turns and when you take it off nicely it sits there without any problem.

So, using this combination of, I would not call it rework using a combination of second operation and using a shaft, it Is possible for you to achieve much much closer fits and things work for a very long time and a lot depends on the metallurgy status of lubrication and how things work. Otherwise you would not be having all that old type of vehicles, old type of sewing machines typewriters and anything you have in you are house and if you are a romantic about an old thing, they were made in small numbers and usually closely inspected and expensive at that time.

But right now, even you can buy a very beautiful a combination programmable sewing machine does not cost too much. It is much much inexpensive compared to the old fab machines or compared to now the various other machines and similarly, when you are going to apparel work; they have machines which work at very high speeds and you do not have a treadmill you do not have a hand instead you have a big motor and sometimes there is a pressurized case in which all the oil is recirculated its pumped inside.

Hence, things like if you take a tough material like jeans or if you take certain huge curtains made of thick materials they are just fed and in one shot like no it will be things it will be moving at great speed. The secret is what started as a almost you know handcrafted devices have now become automated and why I am mentioning it, I am not deviating I just wanted to tell you that all this is now possible for us to make instead of that manual drafting.

If you make a proper 3D model and if you mentioned this tolerances and relevance and if you also work closely with these various things, that are mentioned here. Medium drive for ordinary steel parts are shrink parts on light sections, tutus with usable with cast iron. You may have wondered how sleeves are fitted into a internal combustion engine, that whole outer casing is made of anything. Right now its aluminum, otherwise earlier it is to be variants of cast iron and steels and you have sleeve which have just to go inside.

So, what is done is the sleeve is kept a cooled oil and the casting is probably a little warmer than ambient. So, that it expands a little while this is closed and just by hand things are pushed. Once they are pushed by hand they just locked permanently. Once the temperature comes back to the normal and imagine that if you have a cylinder liner it is always hotter than the usual ambient they just after a little bit of running in it sits permanently, there is no other way of knocking it of some of them have a prohibition of pulling it out otherwise they probably machine it and put some other things.

And, coming back to this things like pistons and the what you call cylinders they come with grades printed on them saying depending on the type of liner you have depending on the type of reburying you do, you can select a different piston. And, even there you have piston rings which need to have these things may being a mechanical engineer the stress is a little more on this.

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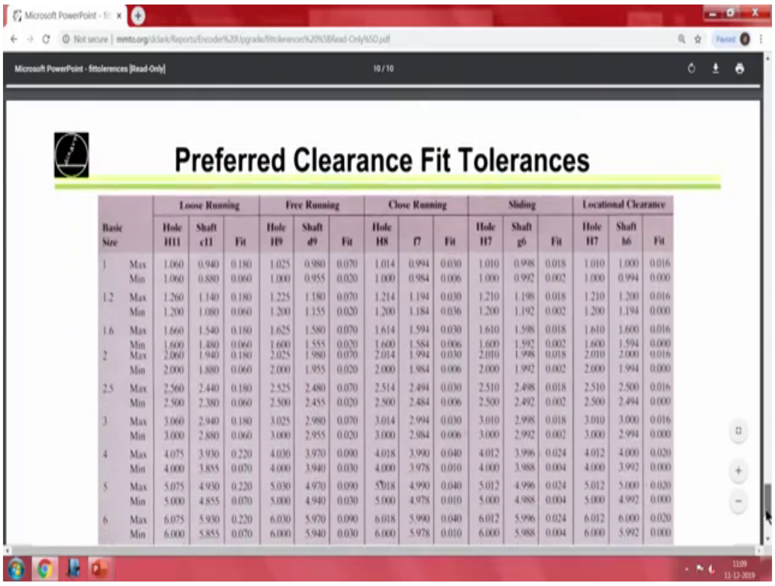

So, we have here a big clearance fit table and it shows under all conditions how things run and so on. Basic size at 1 millimeter and it goes on and on like this and then, we have all these things which are happily they work peacefully without the slightest, what you call a confession on the workshop premises.

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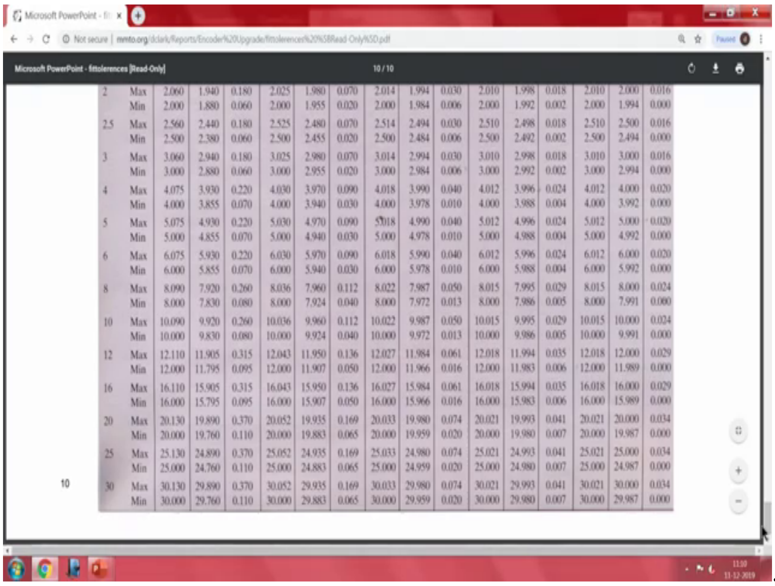

2	Max	2.060	1.940	0.180	2.025	1.980	0.070	2.014	1.994	0.030	2.010	1.998	0.018	2.010	2.000	0.016
	Min	2.000	1.880	0.060	2.000	1.955	0.020	2.000	1.984	0.006	2.000	1.992	0.002	2.000	1.994	0.000
2.5	Max	2.560	2.440	0.180	2.525	2.480	0.070	2.514	2.494	0.030	2.510	2.498	0.018	2.510	2.500	0.016
	Min	2.500	2.380	0.060	2.500	2.455	0.020	2.500	2.484	0.006	2.500	2.492	0.002	2.500	2.494	0.000
3	Max	3.060	2.940	0.180	3.025	2.980	0.070	3.014	2.994	0.030	3.010	2.998	0.018	3.010	3.000	0.016
	Min	3.000	2.880	0.060	3.000	2.955	0.020	3.000	2.984	0.006	3.000	2.992	0.002	3.000	2.994	0.000
4	Max	4.075	3.930	0.220	4.030	3.970	0.090	4.018	3.990	0.040	4.012	3.996	0.024	4.012	4.000	0.020
	Min	4.000	3.855	0.070	4.000	3.940	0.030	4.000	3.978	0.010	4.000	3.988	0.004	4.000	3.992	0.000
5	Max	5.075	4.930	0.220	5.030	4.970	0.090	5.018	4.990	0.040	5.012	4.996	0.024	5.012	5.000	0.020
	Min	5.000	4.855	0.070	5.000	4.940	0.030	5.000	4.978	0.010	5.000	4.988	0.004	5.000	4.992	0.000
6	Max	6.075	5.930	0.220	6.030	5.970	0.090	6.018	5.990	0.040	6.012	5.996	0.024	6.012	6.000	0.020
	Min	6.000	5.855	0.070	6.000	5.940	0.030	6.000	5.978	0.010	6.000	5.988	0.004	6.000	5.992	0.000
8	Max	8.090	7.920	0.260	8.036	7.960	0.112	8.022	7.987	0.050	8.015	7.995	0.029	8.015	8.000	0.024
	Min	8.000	7.830	0.080	8.000	7.924	0.040	8.000	7.972	0.013	8.000	7.986	0.005	8.000	7.991	0.080
10	Max	10.090	9.920	0.260	10.036	9.960	0.112	10.022	9.987	0.050	10.015	9.995	0.029	10.015	10.000	0.024
	Min	10.000	9.830	0.080	10.000	9.924	0.040	10.000	9.972	0.013	10.000	9.986	0.005	10.000	9.991	0.000
12	Max	12.110	11.905	0.315	12.043	11.950	0.136	12.027	11.984	0.061	12.018	11.994	0.035	12.018	12.000	0.029
	Min	12.000	11.795	0.095	12.000	11.907	0.050	12.000	11.966	0.016	12.000	11.983	0.006	12.000	11.989	0.000
16	Max	16.110	15.905	0.315	16.043	15.950	0.136	16.027	15.984	0.061	16.018	15.994	0.035	16.018	16.000	0.029
	Min	16.000	15.795	0.095	16.000	15.907	0.050	16.000	15.966	0.016	16.000	15.983	0.006	16.000	15.989	0.000
20	Max	20.130	19.890	0.370	20.052	19.935	0.169	20.033	19.980	0.074	20.021	19.993	0.041	20.021	20.000	0.034
	Min	20.000	19.760	0.110	20.000	19.883	0.065	20.000	19.959	0.020	20.000	19.980	0.007	20.000	19.987	0.000
25	Max	25.130	24.890	0.370	25.052	24.935	0.169	25.033	24.980	0.074	25.021	24.993	0.041	25.021	25.000	0.034
	Min	25.000	24.760	0.110	25.000	24.883	0.065	25.000	24.959	0.020	25.000	24.980	0.007	25.000	24.987	0.000
30	Max	30.130	29.890	0.370	30.052	29.935	0.169	30.033	29.980	0.074	30.021	29.993	0.041	30.021	30.000	0.034
	Min	30.000	29.760	0.110	30.000	29.883	0.065	30.000	29.959	0.020	30.000	29.980	0.007	30.000	29.987	0.000

You can easily specifies these things in the drawing. And, now again one more time let me tell you in the new type of software where solid modeling is done, there is a provision for you to include all these things in that. So, you are seen that bush first drawing if you see if you remember I will take you back to the very very first drawing.

It is possible now you mention a proper type of fit here, you mention a proper type of allowance here or clearance fit and due to some optimization or something let us say you decide to change the shaft saying instead of a 6 millimeter shaft or I will put it the other way instead of a one-eighth inch shaft which is going to be three point something something which will change to a 3.2, because the quarter inch is 6.35. So, that the other shaft could be 3.175 and the new shaft we have is 3.2 millimeters which is slightly different or you may end up with the 3 millimeter shaft.

Now, you have the advantage of you know you can play with all these things and at one place if you change all of the other things will be taken care of it also involves that you mention what is the minimum material that is required for the bush. So, the full fledged assembly software, all these things are peacefully built into the software and I mean life goes on without the slightest thing life goes on peacefully.

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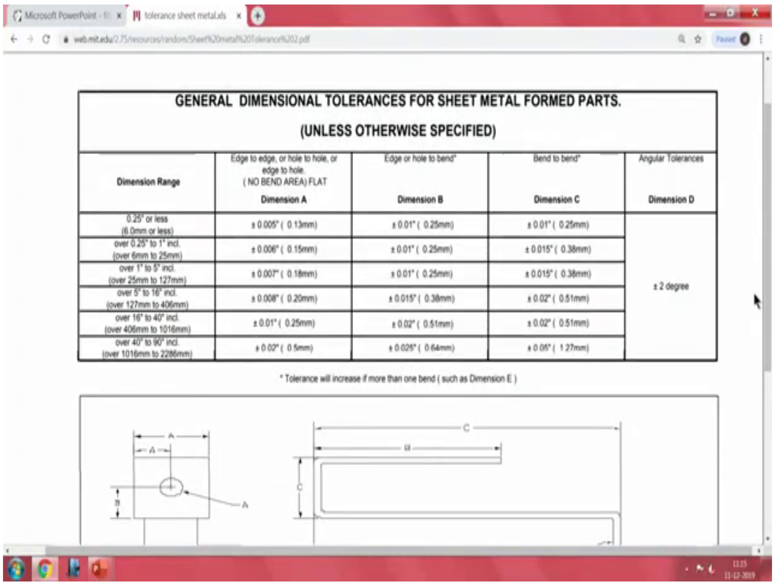
GENERAL DIMENSIONAL TOLERANCES FOR SHEET METAL FORMED PARTS.

(UNLESS OTHERWISE SPECIFIED)

Dimension Range	Edge to edge, or hole to hole, or edge to hole. (NO BEND AREA) FLAT Dimension A	Edge or hole to bend* Dimension B	Bend to bend* Dimension C	Angular Tolerances Dimension D
0.25" or less (6.0mm or less)	± 0.005" (0.13mm)	± 0.01" (0.25mm)	± 0.01" (0.25mm)	± 2 degree
over 0.25" to 1" incl. (over 6mm to 25mm)	± 0.006" (0.15mm)	± 0.01" (0.25mm)	± 0.015" (0.38mm)	
over 1" to 5" incl. (over 25mm to 127mm)	± 0.007" (0.18mm)	± 0.01" (0.25mm)	± 0.015" (0.38mm)	
over 5" to 16" incl. (over 127mm to 406mm)	± 0.008" (0.20mm)	± 0.015" (0.38mm)	± 0.02" (0.51mm)	
over 16" to 40" incl. (over 406mm to 1016mm)	± 0.01" (0.25mm)	± 0.02" (0.51mm)	± 0.02" (0.51mm)	
over 40" to 90" incl. (over 1016mm to 2286mm)	± 0.02" (0.5mm)	± 0.025" (0.64mm)	± 0.05" (1.27mm)	

* Tolerance will increase if more than one bend (such as Dimension E)

So, if I now go back to the most of our electronic enclosures end of it being made with sheet metal and sheet metal by definition somehow it just means a any flat shade, but by metal by default is assumed that it is made with one type of a cold rolled sheet with a particular type of carbon composition and all which we called mild steel.

So, do not be upset if it is just a sheet metal and people give you something which is just made out of cold rolled sheet, that is the common thing whenever somebody says, it is made of sheet metal it is like the change added to that we also have generally it also comes with various types of finishes on top of it. And, why I mentioned finishes is cadmium has been found out to be dangerous a cadmium is not used anymore, but nickel is instead, nickel or in the case of if a price is lower zinc is coated like that.

All these things including the zinc plating including the what you call basic material and depending on the types of processes that are used are very critical when we specify the various types of tolerances and fits on our dimensions. So, I will stop here, I will try to come back later on. I will just stop here and go back a little and then explain this to me to you in the next lecture.

So, far I have just talked about the very very basic fits and tolerances and why it is important for us to put them into a drawing, because manufacture is not like just simply you make a drawing and somebody will you know work on it. If we do that we will again be coming back to just maybe taking an old drawing and then trying to digitize it and then let things go with that new provision we have the original model can have all the fits and tolerances built into it and when the file is transferred to the fabrication people it can be directly probably what is called a machine codes can be generated it and then they fabricated parts can be made out of it.

So, I will go back, I will come back to this later which is very big way things edge hole to the bend ok, bend to bend. What is the tolerance is there on then angular tolerances, edge to edge or hole to a hole. If you recollect seeing workshop video which was I think part of lecture seven or eight after the bending you see there is a peculiar spring back available into that.

So, they will try their best in this case ours is a folding machine at the back there is certain stops. So, you have to ensure that compensate for this spring bag the part that comes out is practically usable it is not 100 percent 90 degrees, but the is tolerance of plus or minus two degrees are built inside there are some adjustments in that which ensures that the liver with it operating stops there.

So, thank you I will get back next time.

Thank you.